NUI Galway
OÉ Gaillimh

# ***Semester 2 Examinations 2015/ 2016***

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| **Exam Code(s)** | 4BCT, 1SD, 1MF, 4BS |
| **Exam(s)** | 4th Year B.Sc. (CS&IT)<br>Higher Diploma in Applied Science (Software Design & Development)<br>Masters in Software Design & Development<br>4th Year B.Sc. |
| **Module Code(s)** | CT404, CT336 |
| **Module(s)** | Graphics and Image Processing |
| Paper No. | |
| Repeat Paper | |
| External Examiner(s) | Prof. L. Maguire<br>Dr. J. Power |
| Internal Examiner(s) | Prof. G. Lyons<br>Dr. J. Duggan<br>* Dr. S. Redfern |
| ***Instructions:*** | Answer any three questions.<br>All questions carry equal marks. |
| ***Duration*** | 2 hours |
| **No. of Pages** | 5 |
| **Discipline(s)** | Information Technology |
| **Course Co-ordinator(s)** | |

**Requirements**:

| | | | | |
|---|---|---|---|---|
| MCQ | Release to Library: | Yes | X | No |
| Handout | | | | |
| Statistical/ Log Tables | | | | |
| Cambridge Tables | | | | |
| Graph Paper | | | | |
| Log Graph Paper | | | | |
| Other Materials | | | | |
| Graphic material in colour | Yes | | No | |

**PTO**

**Q.1. (Graphics)**

(i) Explain the concept Nested Coordinate System as it applies to computer graphics. Why are nested coordinate systems useful? [6]

(ii) Provide short sections of code illustrating the use of nested coordinate systems in both Canvas/Javascript, and in X3D [8]

(iii) Antialiasing is an approach in 2D raster graphics, which uses colour (depth) as a means to simulate an increase in resolution. With reference to the 'G' figures illustrated below, discuss the antialiasing technique, and in particular the concept of sub-pixel accuracy. [6]

**Q.2. (Graphics)**

(i) Describe the use of extrusion in X3D, referring to each of the seven fields used by the Extrusion node. Note that extrusion and other useful nodes from the X3D language are summarised on the final page of this exam paper. [5]

(ii) Write X3D code to make the 3D model of a glass-topped table as illustrated. Note the tapering shape of the legs, and the circular buffers between the legs and the table-top.

Include a diagram of your model showing its measurements, and make the model as geometrically accurate as possible [10]

Define Materials for the model: the legs are a diffuse brown colour, and the top is semi-transparent [5]

**Q.3. (Graphics)**

(i) What are surface normals? Why are they essential to surface shading algorithms? Refer to Lambert Shading and Gourard Shading. Use diagrams to illustrate your answer. [8]

(ii) Two powerful techniques for rendering shadows in realtime 3D environments are radiosity, and ambient occlusion. Explain these techniques in simple terms, drawing attention to their suitability for pre-runtime computation. [6]

(iii) With respect to 3D graphics rendering, define the terms: specular colour, diffuse colour, ambient lighting. Illustrate each term with a diagram. [6]

**Q.4. (Image Processing)**

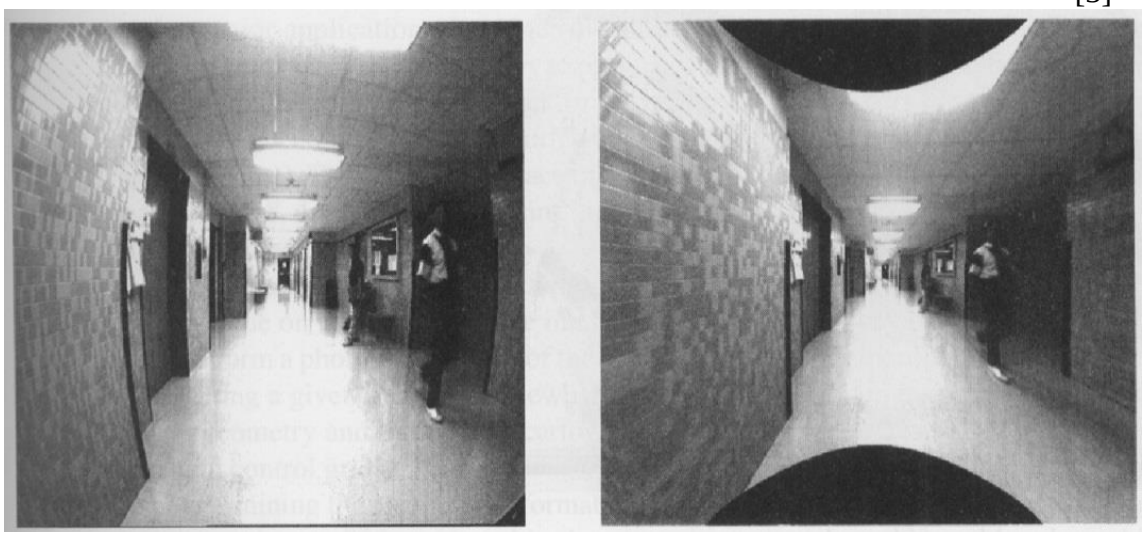
(i) With respect to morphological image processing, outline the following operations: erosion, dilation, opening, and closing, as applied to binary images. [8]

(ii) The image below depicts a number of circular buttons on a table. Outline a suitable series of image processing operations for automatically counting the number of buttons. Explain why your solution is appropriate, and briefly explain the details of each proposed step. You will need to deal with: noise, varying background brightness, the fact that some buttons are touching or overlapping, and the fact that many of the buttons have dark patterns on them. [12]

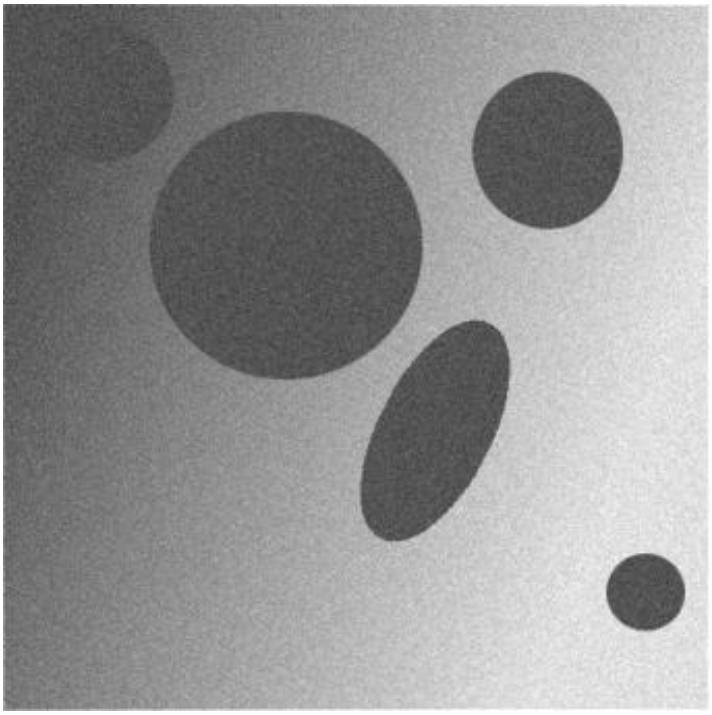
**Q.5. (Image Processing)**

(i) Camera decalibration is a technique for geometric correction of images which is often employed when sources of geometric error are poorly understood. With regard to camera decalibration:

- Outline the use of reference images such as grids of dots to construct and apply geometric corrections to images captured with a wide-angle lens (e.g. the image below). Use the terms 'control points', 'pixel filling', and 'bilinear interpolation' in your answer. [7]
- Explain why would you expect a reference image to be constructed with black markings on a white background (or white markings on a black background) [3]



(ii) In many cases, it may not be possible to robustly segment an image based on detected edges. One solution is to apply template matching approaches such as the Hough Transform. Explain in simple terms the operation of the Hough Transform as it applies to circles, indicating why it might be a good choice for automatic extraction of circle-like shapes such as those depicted in this noisy image. [10]



## Some useful X3D nodes:

| Node | Important Fields and Nested Nodes |
|---|---|
| Shape | Nested Nodes: Appearance, Geometry Nodes (Box, Sphere, Cone, Cylinder, Text, Extrusion, etc.) |
| Appearance | Nested Nodes: Material, ImageTexture |
| Material | Fields: diffuseColor, specularColor, emissiveColor, ambientIntensity, transparency, shininess |
| ImageTexture | Fields: url |
| Transform | Fields: translation, rotation, scale, center.<br>Nested Nodes: Other Transforms, Shapes, Sensors |
| TimeSensor | Fields: enabled, startTime, stopTime, cycleInterval, loop |
| PositionInterpolator | Fields: key, keyValue |
| OrientationInterpolator | Fields: key, keyValue |
| Extrusion | Fields: crossSection, spine, scale, orientation, beginCap, endCap, creaseAngle |
| Box | Fields: size |
| Sphere | Fields: radius |
| Cylinder | Fields: radius, height, side, top, bottom |
| Cone | Fields: height, bottomRadius, side, bottom |
| PointLight | Fields: on, location, radius, intensity, ambientIntensity, color, attenuation |
| ROUTE | Fields: fromNode, fromField, toNode, toField |

## Some useful methods/properties of the Canvas 2D Context object:

| Method/Property | Arguments/Values | Notes |
|---|---|---|
| fillRect | (Left, Top, Width, Height) | Draw a filled rectangle |
| beginPath | None | Start a stroked path |
| moveTo | (X, Y) | Move the graphics cursor |
| lineTo | (X, Y) | Draw a line from graphics cursor |
| stroke | None | End a stroked path |
| fillStyle | ="rgb(R,G,B)" | Set fill colour |
| strokeStyle | ="rgb(R,G,B)" | Set line colour |
| save | None | Save the current coordinate system |
| restore | None | Restore the last saved coord system |
| translate | (X,Y) | Translate the coordinate system |
| rotate | (angle) | Rotate the coordinate system clockwise, with angle in radians |
| scale | (X,Y) | Scale the coordinate system independently on the X and Y axes |